United States
Department of
Agriculture

Forest Service

Pacific Northwest
Forest and Range
Experiment Station

Research Paper
PNW-308
September 1983

Potential for Economical Recovery of Fuel From Land Clearing Residue in Interior Alaska

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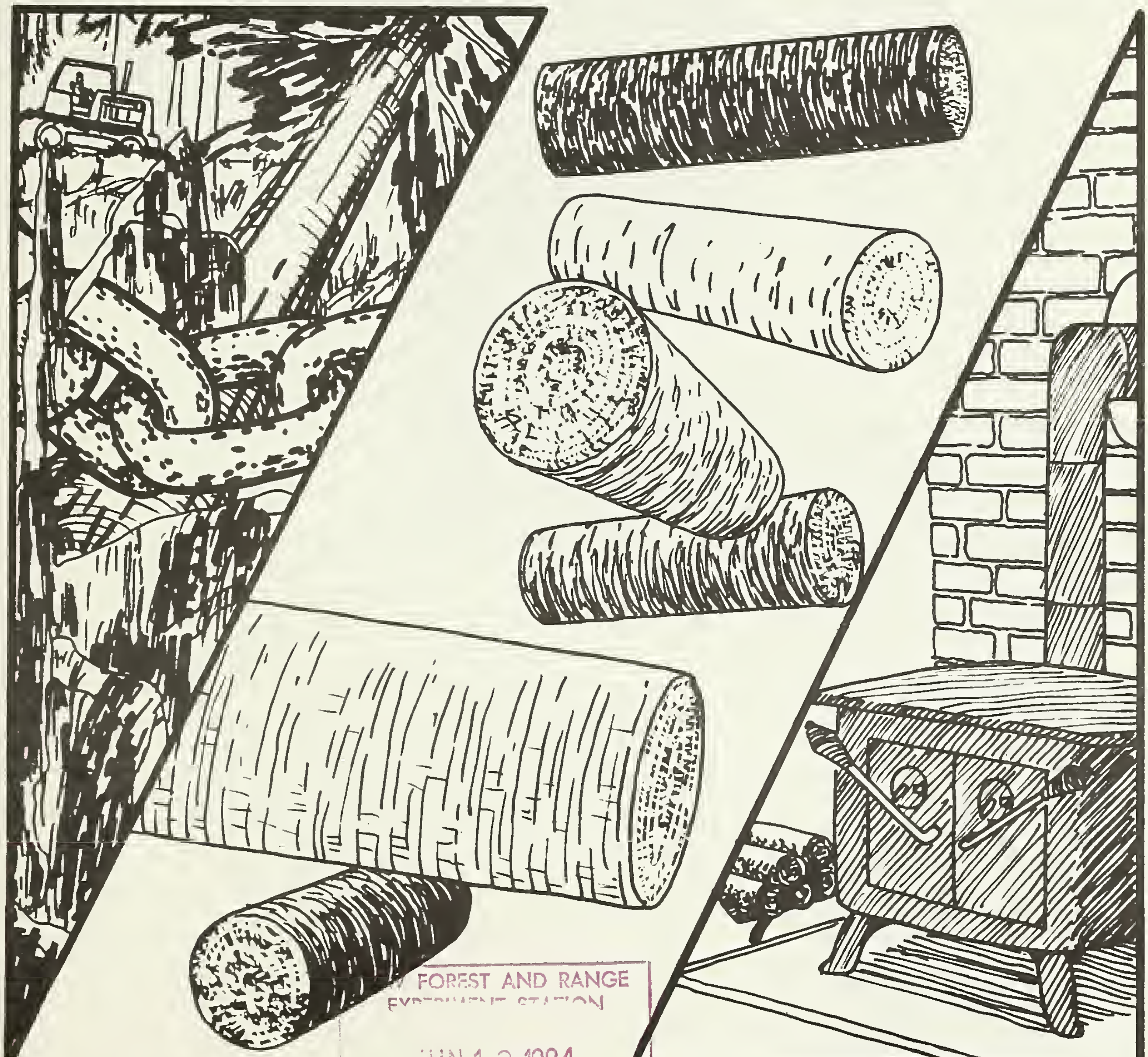

Authors

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Abstract

Sampson, George R.; Ruppert, Forrest A. Potential for economical recovery of fuel from land clearing residue in interior Alaska. Res. Pap. PNW-308. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1983. 11 p.

Unusable tree and moss residues from land clearing projects in interior Alaska were collected, milled, dried, and densified into fuel logs. Four different combinations of species were tried, and all produced suitable fuels. The feasibility of commercially producing this material into densified fuel in interior Alaska is limited because the fuel logs tend to expand or decompress during winter storage in unheated buildings there.

Keywords: Wood waste utilization, fuel (waste wood), fuel (pressed wood), energy, residues.

Summary

Land clearing for agricultural use in interior Alaska results in residue that must be disposed. The residue could have potential use as home heating fuel. Researchers studied the feasibility of economically converting land clearing residue into densified fuel logs.

A manufacturer of densified fuel logs made from plywood mill residue, located in Grants Pass, Oregon, produced experimental fuel logs using four types of land clearing residue from interior Alaska: black spruce, moss, a mixture of paper birch and aspen, and a mixture of moss and black spruce. The logs were 3 inches in diameter and 10 inches long. People who burned the experimental fuel logs in their home heating systems liked spruce and the mixture of paper birch and aspen, but they generally did not like the moss fuel logs as well as firewood. The moss logs burned slowly, smoked, and left a high proportion as ash. Fuel logs stored in covered but unheated storage over winter tended to decompress during the transition to summer; fuel logs stored in covered, heated buildings did not.

The costs of manufacturing densified fuel logs from land clearing residue in interior Alaska make the product marginally competitive with firewood. Capital investment, however, is quite high, and a large share of the local firewood market would have to be captured for a manufacturing plant to be profitable.

Introduction

A large-scale program to develop agriculture in Alaska was begun by the State of Alaska in August 1978. Nearly 60,000 acres of State land in the Delta Junction area, southeast of Fairbanks, were transferred by sale of agricultural rights to private interests for clearing and conversion to crop land. This first agricultural sale by the State is referred to as the Delta Agricultural Project (fig. 1). The sale was followed by disposal of 24,425 acres in Delta II East in 1982. Other small-scale disposals have been made for agriculture, and more disposals—both large- and small-scale—are planned for the future.

Many owners clear tree cover from their land by dragging a ship anchor chain between two large crawler tractors. Because of fire hazard, the chained material cannot be burned in place; trees and the underlying moss layer are pushed into berm rows (fig. 2). After drying for a summer, the berm rows are burned in late fall or winter. Repeated burnings are necessary over several years before the material is reduced enough to be removed. The practice has been to farm between the berm rows until all the material is finally removed.

If merchantable sawtimber were harvested prior to chaining, a substantial volume of woody biomass and the moss layer would still remain as a disposal problem. Many of the black spruce stands contain no merchantable timber. The volume of biomass in a typical lowland black spruce stand is summarized in table 1. The majority of the biomass in such stands is in the moss layer.

One alternative to burning the biomass onsite is to remove and utilize it as a fuel (Eakin 1979, Lewis 1979). This would almost certainly require that the biomass be chipped onsite and be dried and densified at a nearby location. Most of the commercial wood densifying operations in existence today use dry sawmill or plywood residue as raw material. It was not known whether the kinds of biomass present on a typical site could be successfully processed through a commercial densifying operation to produce fuel logs or briquettes.

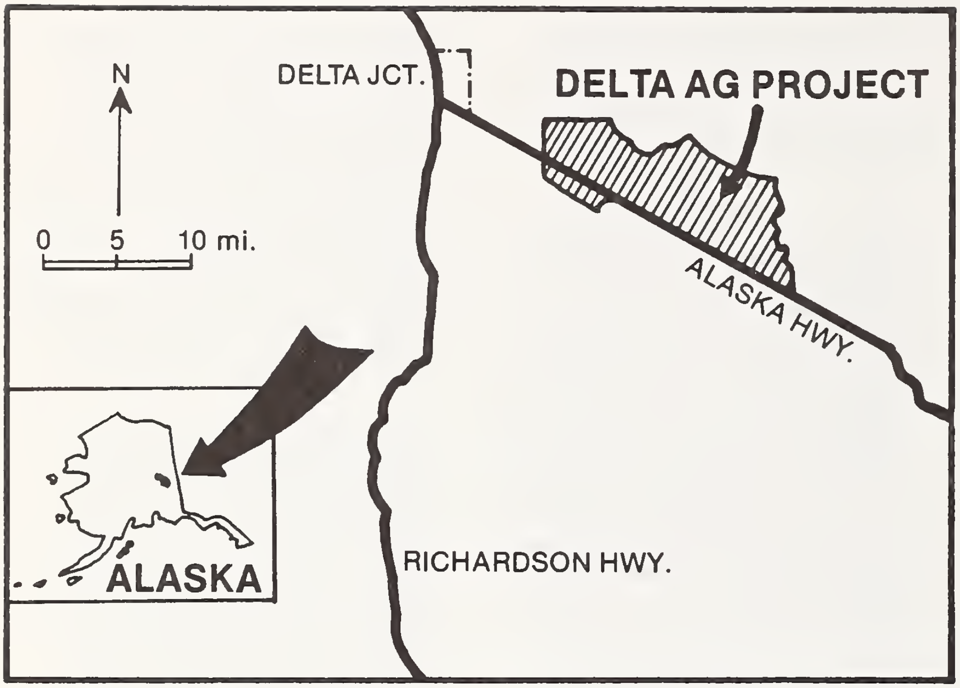

Figure 1.—Location of the Delta Agricultural Project.

Table 1—Composition of biomass in a "typical" lowland black spruce stand in interior Alaska

Type of biomass	Tons/acre	Percentage of total biomass
Moss, upper layer	17.14	26.5
Moss, lower layer	37.50	58.0
Standing overstory tree material	7.19	11.1
Standing dead timber	.98	1.6
Dead and down timber	1.17	1.8
Herbaceous vegetation	.66	1.0

Source: Eakin and others 1979.

Figure 2.—The land clearing operation in the black spruce type in interior Alaska: *A*, trees are uprooted by chaining; *B*, chained material is piled into berm rows and burned.

Purpose of the Study

The purpose of our study was to determine if a densified fuel could be made from typical land clearing residue from interior Alaska and to determine the characteristics of such a fuel, if it could be successfully produced. Whether or not it is feasible to make a fuel from land clearing residue is an important question; there are plans to have 500,000 acres of land cleared for agriculture in interior Alaska by 1990. Virtually all of this land is covered by forest and moss.

Methods

Four types of material were selected for study: (1) the moss layer under a typical black spruce (*Picea mariana* (Mill) B.S.P.) stand, (2) whole tree black spruce, (3) a mixture of moss and black spruce, and (4) a mixture of paper birch (*Betula papyrifera* Marsh.) and aspen (*Populus tremuloides* Michx.). All materials were collected on or adjacent to the Delta Agricultural Project. The moss layer, which includes all organic matter in this forest floor above mineral soil, was collected by hand in an undisturbed black spruce stand to minimize the amount of dirt and stones in the sample. Black spruce trees were taken from material in berm rows that had already been chained and piled. Whole trees were taken, including attached roots, needles, twigs, and bark. For the paper birch-aspen mixture, whole trees were taken including the bole, bark, twigs, and leaves, but excluding roots.

The residue, each type kept separate, was shipped by barge from Alaska and trucked to Washington State University where it was hammermilled and dried. Wood materials were chipped and then processed through a small industrial size hammermill with a 5/8-inch screen. Three different particle sizes were produced from the moss samples. Coarse moss was material that did not pass through a number 4 Tyler[1] screen (sieve with 0.187-inch openings). Medium moss passed through a number 4 screen, but not a 32 screen (sieve with 0.0197-inch openings). Fine moss passed through a number 32 screen. The material was then shipped to Fourply, Inc. at Grants Pass, Oregon, for densification. Different combinations of all materials were made based on nearly dry weight (about 10 percent moisture content). The moss-black spruce mixture was 70 percent moss and 30 percent black spruce. The paper birch-aspen mixture was 60 percent paper birch and 40 percent aspen.

[1] Trade and company names are used for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

The residue was mixed in appropriate proportions at Fourply, Inc. Proper proportions were weighed out then mixed with shovel in a pickup bed. The combinations of material represented what will likely be encountered on land clearings in interior Alaska. Much of the land to be cleared is covered by black spruce underlain by a thick layer of moss, represented by the mixture of moss and black spruce. It would also be possible to harvest either the moss or black spruce separately. Other lands to be cleared are covered by mixed stands of paper birch and aspen with little moss beneath the stands. The most appropriate way of removing this timber is to shear it at or near ground level, taking the entire tree.

All material was processed through the commercial fuel log machine.[2] In the process, a 3-inch diameter continuous log was extruded into a long cooling line, then was broken into 10-inch lengths by a pneumatic device. The individual logs were carried by conveyor belt to the packaging area.

Samples of each type of experimental fuel and commercial product produced were sent to the University of Washington where calorific values and residual ash content were determined. Samples of the experimental fuel logs were given to interested individuals around Portland, Oregon, and Fairbanks, Alaska, for burning in their home wood-burning stoves or fireplaces. These individuals were given a questionnaire which asked them to subjectively compare the experimental fuel logs with their usual fuel. Samples of each type fuel log were placed in both covered and exposed storage in the Fairbanks area to determine long-term deterioration rates.

[2] A Hausmann Briquettor manufactured by Fred Hausmann, Ltd., of Basel, Switzerland. The machine is operated by Fourply, Inc., of Grants Pass, Oregon.

Results

With one exception, all types of material were compressed into fuel logs with no major production problems (fig.3). The fine moss material that passed through a number 32 screen did not process well because of excess friction in the cooling line at start up. This fine moss material looked and felt like very fine sand and, in fact, contained a high proportion of fine soil particles. When mixed with wood particles or larger size moss material, however, the fine moss processed satisfactorily. Except for the very fine moss, there were no differences noted in how effectively the raw materials were densified. There were no additives: the process depended only on pressure for successful densification. Weights of the fuel logs produced during the test run are summarized in table 2. Weights per fuel log are greatest for moss, followed by moss-spruce, spruce, then birch-aspen. This is a direct reflection of density of the parent material.

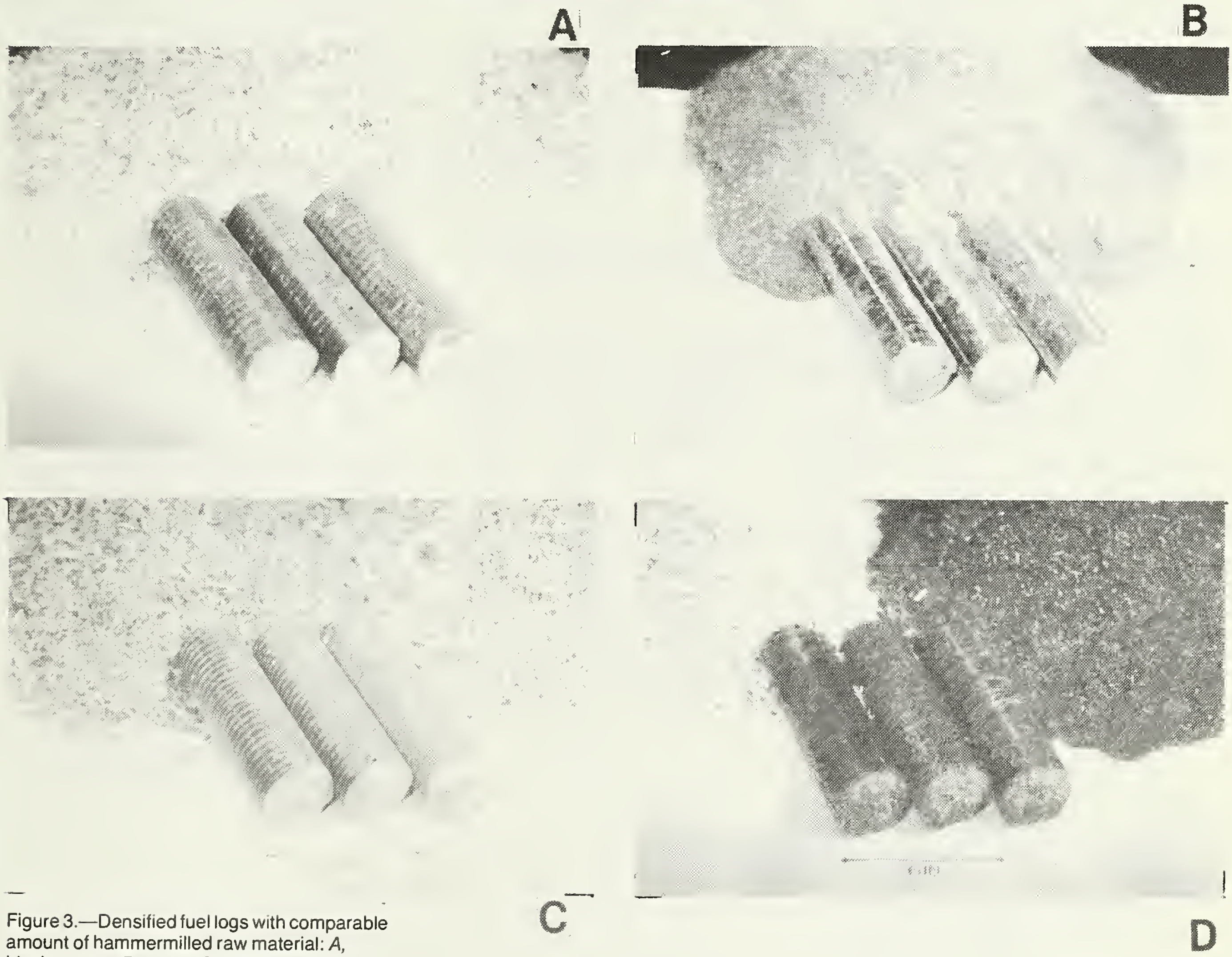

Figure 3.—Densified fuel logs with comparable amount of hammermilled raw material: *A,* black spruce; *B,* moss, *C,* mixture of paper birch and aspen; *D,* mixture of moss and black spruce.

Table 2—Weight of fuel logs produced from land clearing biomass in interior Alaska by type of material

Type of material	Number of fuel logs weighed	Weight per fuel log		
		Range	Average	Coefficient of variation
		------- Ounces -------		percent
Birch-aspen mixture	30	45-46	45.5	1.1
Spruce	30	46-48	47.1	1.2
Coarse moss	30	51-57	53.4	2.7
Medium moss	30	53-60	56.4	2.6
Moss-spruce mixture	30	51-56	53.3	2.8
Commercial product 1/	15	44-46	44.7	1.1

[1] Produced from a mixture of Douglas-fir, ponderosa pine, and white fir veneer and plywood trimmings.

Table 3—Higher heating values and ash content of samples from fuel logs produced from land clearing biomass in interior Alaska by type of material 1/

Type of material	Number of samples	Higher heating value		Ash content	
		Average	Coefficient of variation	Average	Coefficient of variation
		BTU/pound	percent	percent	percent
Birch-aspen mixture	32	8686	1.6	1.5	33.3
Spruce	32	8767	0.6	1.7	47.1
Coarse moss	32	6734	2.7	24.8	8.5
Medium moss	32	6429	6.5	29.7	3.0
Fine moss	6	4505	23.6	47.8	4.4
Moss-spruce mixture	32	6927	4.5	24.1	18.7
Commercial product 2/	31	8771	6.3	1.2	4.4

[1] Values are based on ovendry weight.
[2] Produced from a mixture of Douglas-fir, ponderosa pine, and white fir veneer and plywood trimmings.

Initial plans were to determine breakage of fuel logs as they came from the conveyor belt. The only breakage that occurred, however, was in briquettes produced immediately after changing to a different raw material type. A sample of the fuel logs was put in cardboard boxes, placed on pallets, and shipped from Oregon to Alaska by commercial ocean freighter. By the time the fuel logs arrived in Fairbanks they had been handled at least four different times, enough to be an adequate test of breakage in transit. There was no evidence of fuel log breakage on arrival in Fairbanks.

The maximum potential energy or higher heating values of samples from the fuel logs are shown in table 3. Spruce had the highest heating value at about 8800 BTU's per pound, followed by birch-aspen at 8700, moss-spruce at 6900, coarse moss at 6700, medium moss at 6400, and fine moss at 4500. Table 3 also shows ash content: the relationship is the inverse of energy content. The values of energy and ash content obtained are approximately what was expected, with the exception of the medium moss and, particularly, the fine moss. The decreasing energy content and increasing ash content as moss particle size decreased were apparently the result of increased mineral content, principally soil.

Individuals who burned some of the fuel logs in their home heating systems liked the nonmoss fuel as well or better than their usual firewood (table 4). They generally did not like the moss fuel logs as well as their usual fuel, however, because they burned slowly and had a high ash content.

Table 4—Results of subjective burning tests of experimental fuel logs compared to usual fuel of split firewood in home heating systems

Question asked user	Type fuel log burned			
	Paper birch-aspen	Black spruce	Moss	Moss-black spruce
	Number of responses			
Did you have a problem igniting the fuel log?				
Yes	4	5	8	7
No	7	8	2	1
No answer	1	1	0	0
Does it heat as well or better than your usual fuel?				
Yes	9	9	1	4
No	3	3	8	4
No answer	0	2	1	0
Is as clear or clearer than your usual fuel?				
Yes	11	9	4	3
No	0	3	6	5
No answer	1	2	0	0
Did the fuel log burn as long or longer than your usual fuel?				
Yes	6	6	8	8
No	4	4	2	0
No answer	2	4	0	0

The fuel logs were resistant to disintegration from very humid conditions when exposed for a short time. That is, they survived several days on an ocean barge with no ill effects. Initially, they also appeared resistant to disintegration from very dry conditions or from changes in temperature (-40°F to 90°F). Fuel logs stored over winter in covered but unheated storage, however, expanded linearly 25 to 30 percent with the advent of summer temperatures. We suspect this was caused by a combination of high relative humidity and repeated freezing and thawing. Generally, the spruce fuel logs showed greatest expansion, followed by paper birch-aspen and then fuel logs derived from moss material.

Some logs were stored together in a greenhouse over winter and were taken outdoors to be photographed in May (fig. 4). The spruce fuel log had expanded from its original 10 inches to 13, birch-aspen to 12, and moss to about 11 inches. Other logs were placed outside in November. They remained intact after a light snow when temperatures remained well below freezing, but rain initiated rapid disintegration (fig. 5). Covered storage and transport of fuel logs is therefore essential at all times. Fuel logs stored in heated space have not shown a tendency to disintegrate.

Extruded particle board, which should have characteristics similar to extruded fuel logs, has a tendency to swell in the lengthwise direction because of the compression and orientation of particles from the extrusion pressures (U.S. Department of Agriculture, Forest Service 1974). A recently completed study concluded that none of the current commercial processes can densify biomass into fuel without a binder to produce a product that is water stable—one that can be stored exposed to weather 60-90 days (Levelton and Associates Ltd. 1981).

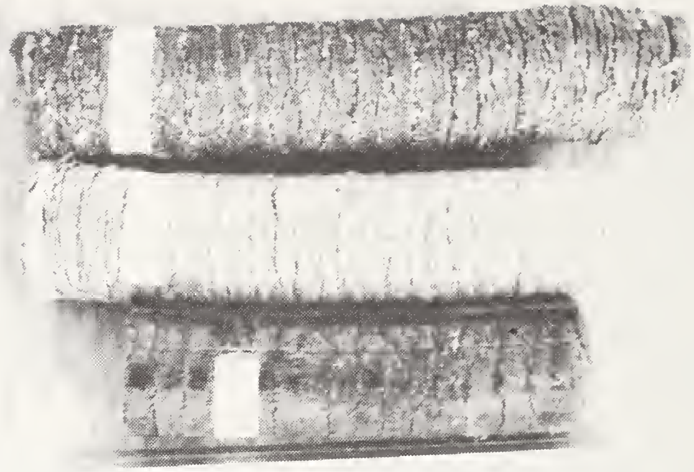

Figure 4.—Expanded fuel logs after winter storage in an unheated greenhouse. From top to bottom: spruce, birch-aspen, and moss.

Figure 5.—Disintegrated logs stored outdoors.

Discussion

Procedures used in this study to collect and process the material involved much hand labor and were not typical of practices that would be employed by a commercial operation. A commercial operation would likely chip raw material directly from berm piles. Proper clearing technique requires that about 2 inches of moss layer be left behind when the material is piled. The remaining moss is then incorporated into the soil during tilling. Thus, there should be a minimum of free soil and dirt in the berm piles. Some soil and rocks may cling to tree roots after uprooting, but most would be dislodged and screened out in the chipping process and would not affect the densification process. There is, however, a substantial quantity of mineral matter incorporated in the moss layer in the Delta Junction, Alaska, area that cannot be removed by any known practical means. Its presence is the result of decades of windblown particles being taken from glacial streambeds, deposited in trees, then filtered into the moss layer. This incorporated soil did not appear to directly affect either the chipping of our raw material or the densification of our sample fuel logs, but the densified moss had a coal-like appearance, being black in color. The major disadvantage of the incorporated soil is the large proportion left as residual ash after burning—the ash content of the moss is 25-30 percent by weight. The high residual ash in moss is undoubtedly a function of geographic location. Preliminary tests of moss from the Little Chena River drainage northeast of Fairbanks indicate only 3 to 7 percent residual ash.

Material left in berm piles for more than a year will undoubtedly begin to decay, yet the decay does not appear to be a problem when the material is chipped or densified.

The problem of decompression and subsequent disintegration of fuel logs stored in unheated storage over winter could be avoided by shrink-wrapping the logs in groups of two to four, but only at great increase in cost. The shrink-wrap would have to be burned with the fuel logs, a possibly unacceptable requirement for people heating mainly with wood. The tendency of the fuel to decompress and disintegrate might be less of a problem if it were made into pellets, but expansion of fuel pellets in a bin from which a stoker system operates could present feed problems. Care would have to be taken to insure that the atmosphere around storage bins be quite dry.

Production costs of making fuel logs from land clearing residue are largely dependent on assumptions about what equipment is going to be purchased and operating efficiency. Obviously, an enclosed, heated building is essential for manufacturing fuel logs during the winter in interior Alaska. In addition to a chipper and trucks for hauling chips, a hammermill, drier, and densifier would be needed as well as a shed for storing fuel logs. The most efficient operation we can envision within the size constraints imposed by local markets would require a capital investment of over three-quarters of a million dollars; the operation would produce more than 15,000 tons per year of densified fuel logs (less than one-fourth of the current annual consumption of firewood in Fairbanks North Star Borough). Total costs of field chipping, hauling, and manufacture would be in the range of $55-$65 per ton, making densified fuel logs cost competitive with firewood. Firewood currently commands a delivered price of more than $100 per cord in the Fairbanks area.

Conclusions

The feasibility of commercially producing densified fuel logs from the biomass from land clearing projects remains questionable unless some method is found for preventing the fuel logs from decompressing when they are stored over winter.

It does not appear feasible to densify the moss layer when it has a high mineral content, such as the 25 to 30 percent found in the Delta Junction area. This high mineral content tends to impede the burning rate in home heating systems and also results in an objectionably high residual ash. Moss from areas that are not subject to prevailing winds carrying silt from glacial streambeds may be suitable for densification into fuel logs, but such material was not tested in this study.

Densified fuel logs from land clearing biomass cannot be marketed at a price competitive with coal for large-scale users such as electric utilities with rail access. The fuel logs could be only marginally price competitive with coal for home heating systems in the Fairbanks area or other areas where coal can be brought in by rail. Densified fuel logs can be price competitive with dried, cut-to-length firewood. An investment of about $750,000 would be required to establish a densified fuel log business. Marketing its products would require capturing the equivalent of one-fourth to one-third of the firewood used annually in the Fairbanks North Star Borough. Capturing such a large volume of the market in the span of several years does not appear possible even though public access to timber for firewood has become a problem.

The most economical beginning for producing densified fuel in interior Alaska would be by an operating wood products processing plant that already has a supply of residue onsite and may also have some slack labor available. This would help offset the diseconomies of a small operation, but would enable the entrepreneur to begin production with a small market volume of 2,000 to 4,000 tons per year. Such an operation could expand into using land clearing residue after several years of market development.

Acknowledgment

The U.S. Department of Energy, Region X, Seattle, Washington, provided funds for this study. Fourply, Inc. of Grants Pass, Oregon cooperated in the study by producing the experimental fuel logs.

Literature Cited

Eakin, D. E.; Clark, M. A.; Donavan, J. M. [and others]. Assessment of biomass conversion to energy for Delta Agricultural Project. Richland, WA: Battelle Pacific Northwest Laboratories; **1979.** 49 p.

Levelton, B. H. and Associates Ltd. Development of a moisture resistant densified solid fuel from forest biomass. ENFOR Proj. C-97. Hull, PQ: Canadian Forestry Service, Environment Canada; **1981.** 147 p.

Lewis, Carol E. Alternate uses of tree and moss cover on agricultural lands in interior Alaska. North. Eng. 11(4): 24-28; **1979.**

U.S. Department of Agriculture, Forest Service. Wood handbook: wood as an engineering material. Agric. Handb. 72, rev. [Madison, WI]: Forest Products Laboratory; **1974.** [Not paged].

Sampson, George R.; Ruppert, Forrest A. Potential for economical recovery of fuel from land clearing residue in interior Alaska. Res. Pap. PNW-308. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1983. 11p.

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